# Gradient analysis for fault detection in the Rome Trough


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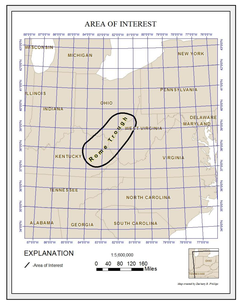
## BACKGROUND

- Knowing the location, position and structure of faults is important for aspects of earthquake epicenter location, seismic hazard and risk analysis, $CO_2$ sequestration, waste injection, and oil and gas migration.
- Faulting in the Rome trough was caused by the uplift of the Appalachian Mountains during the middle Ordovician (440-480 million years ago) to the Pennsylvanian Period (300 million years ago). Reactivation of these faults may be caused by engineering projects beneath the surface.
- Using the grid analysis program Mirone, one is able to perform mathematical analyses to gridded Geographical Information Systems (GIS) data to locate the areas of the dataset with the highest gradient (i.e. a vertical or near vertical fault surface).
- This research was done to give subsurface engineers a better idea of the fault structure and orientation in the sedimentary layers overlying the Precambrian bedrock. Using various layers of structural and isopach data faults can be traced in 3-dimensions in the subsurface.
- Area of interest is the Rome Trough, which is an active area in terms of oil and gas storage, production, and recovery, $CO_2$ storage, and is also an area of past tectonic activity. Very little is known of this area because of its extensive depth.
- With the information gained in this study one will be able to study the trends, lengths, orientation and surface area of faults in the area in three dimensions.




## METHODOLOGY

Acquisition of Midwest Regional Carbon Sequestration Partnership isopach and structure data disc. Data available covers units from early Cambrian to the upper Devonian. This section covers only the basal sandstone to indicate the procedure used.

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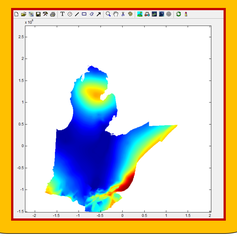
Plotting the acquired gridded Data in the grid analysis program, Mirone.



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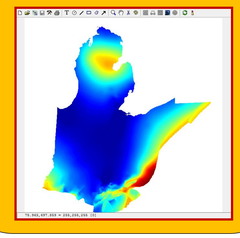
Cropping of grid to get rid of NaN (not a number) values to allow calculation of vertical derivatives in dataset.



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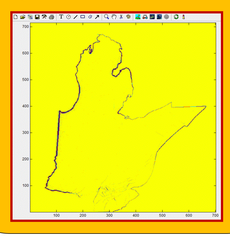
Taking the 2nd derivative of cropped image and pinching the color palette to highlight faults.



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Importing of cropped image in to ArcGIS, georeferencing and tracing of faults using ArcGIS.


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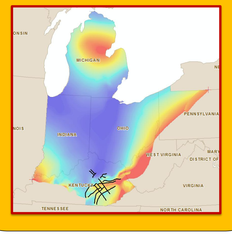
Overlaying original structural data grid showing depth to top of unit that is being mapped.

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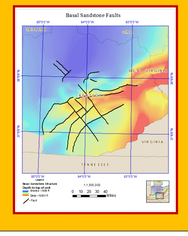
Importing map template for making multiple maps with the same format, each composed of one rock unit.

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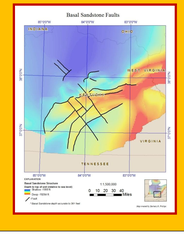
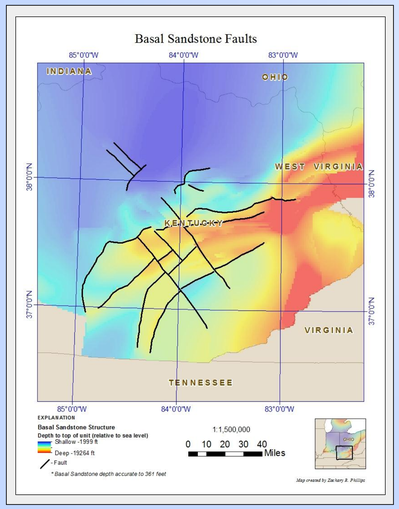
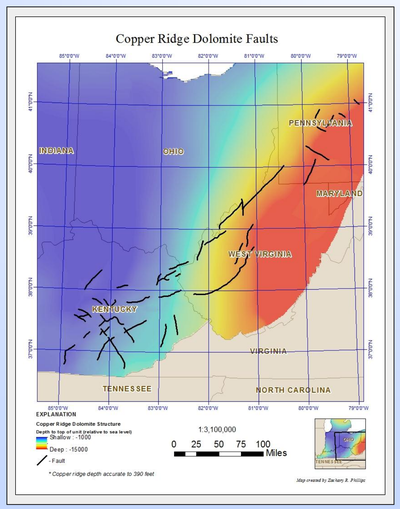
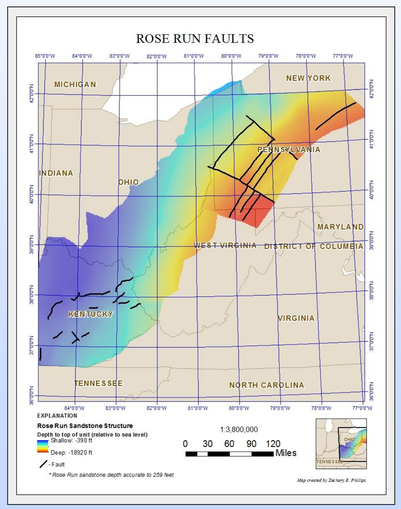
Final printable product with faults and structural data with Latitude/Longitude grid and state lines for reference.

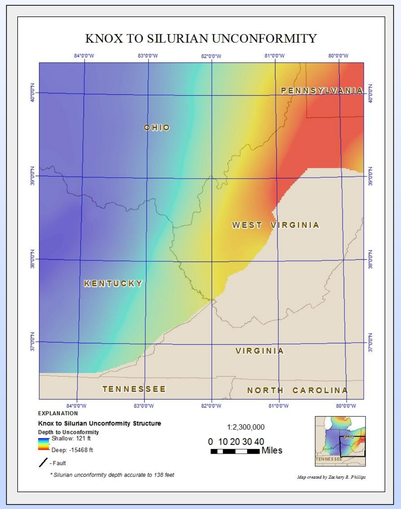



## RESULTS




*Structure maps displaying faulting in three consecutive units in the Rome trough. Notice the lack of faulting at and above the Silurian unconformity.*

## CONCLUSIONS

- Faulting in the Rome trough in eastern Kentucky along two major trend lines, 55.925° east of north and 35.65° west of north.
- Faults penetrate layers between the Basal sandstone (about -11,000 feet) and Rose Run sandstone( about -950 feet), resulting in a vertical penetration of about 10,050 feet (or 3.06 km).
- Analyzing the longest fault detected (with a length of 267.4 km) for surface area results in an area of 818.25 $km^2$.
- Since faults do not penetrate above the Silurian unconformity it can be assumed that the faulting occurred before the unconformity. This would constrain the age of these faults to greater than ~443 million years old.

## REFERENCES


1. Midwest Regional Carbon Sequestration Partnership, (Battelle, Columbus, Ohio), Wagner, W.R. *mrcsp_bsstr*, raster digital data, 1975. [Data CD]. July 13th, 2012.
2. Midwest Regional Carbon Sequestration Partnership, (Battelle, Columbus, Ohio), *mrcsp_crstrg*, raster digital data, Unpublished Material. [Data CD]. July 13th, 2012.
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4. Midwest Regional Carbon Sequestration Partnership, (Battelle, Columbus, Ohio), *mrcsp_rrstrg*, raster digital data, Unpublished Material. [Data CD]. July 13th, 2012.
5. "*Geologic provinces of the united states: Appalachian highlands province*. (January, 13th 2004).